How Strong Is Your Tinder Game? Two-Sided Search in Swipe-Based Dating Apps

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Abstract

In today's modern love market, swipe-based dating apps have a well-established presence, but platform features such as directed search algorithms and swiping caps add significant complexities to the user's search problem that have not been studied in existing literature. This paper formulates a game-theoretic model of two-sided search within swipe-based dating apps and, using numerical computation methods, approximates the steady-state equilibrium. The effects of various model parameters are assesed using comparative statics and replicate stylized facts observed in aggregate Tinder data. Finally, the perspective of the planner to analyse how exogenously-determined platform features (such as the matching algorithm and the swiping caps) can be set to maximise welfare. By analysing how platform design and its implied constraints affect user behaviour, this research aids dating platforms in improving social efficiency and provides a first step towards pricing models for subscriptions, a task of crucial importance considering that over 8 million people purchase subscriptions on Tinder alone.

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Contents

1 Introduction

Points to discuss on introduction

- What is Tinder? (brief)
  - When was it started?
  - What is swiping?
  - How popular it is?
- Why does Tinder pose an interesting economic problem?
  - Stage interaction
  - Platform features: budgets, observability, directed search, asynchronicity
  - Repeated games: curse of dimensionality, beliefs and meta-beliefs
- What and how does this paper study?
  - Model of two-sided search with strategic considerations
  - Equilibrium refinement, computation, and analysis
  - Planner considerations on directed search and budget setting
- What does this paper contribute?
  - First model to address budgeted search in Tinder?
  - First model to combine idiosyncracy and pizzaz
  - Case study for the use of computational techniques in

1.1 Related Work

- Searching and Matching
  - Gale and Shapley (1962), Roth and Sotomayor (1992)
  - Two-sided: Burdett and Wright (1998), Chade (2006), Smith, Adachi
  - **Does not consider budgets**
    - ... important as this is a way for planners to influence outcomes
- Mean-Field Game Theory: Iyer et al. (2014), Gummadi et al. (2013), Jovanovic and Rosenthal (1988)
  - No models on MFG for Tinder
- Modern Dating Apps: Olmeda (2021), Kanoria and Saban (2021)
  - Not models where behaviour is derived from rational utility-maximizing assumptions

2 Model

2.1 Setup

- Who are the players?
  - Disjoint sets of men and women in the platform
  - They have pizzaz type $\mu, \omega \in [0, 1]$
- What do they do?
  - They get anonymously and sequentially partnered up
  - To their knowledge, this happens in a random manner.
  - They observe the suggestion's attractiveness $\theta \in [0, 1]$
  - They can choose to swipe left or right, thus $\mathcal{A} = \{0, 1\}$.
  - If they both swipe right on each other, they match. Note this doesn't mean they leave.
- What do they know?
  - Equally agents face a cap on the number of right swipes they have
  - B_m for men and
- What are their preferences?

2.2 The Dating Market

- Entry flows
- Leaves (including geometric lifetime)
- Distribution

2.3 The Search Problem

3 Equilibrium

3.1 Steady-State Equilibrium

3.2 Numerical Computation

3.3 Comparative Statics

4 Playing Cupid

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4.1 Directed Search: PageRank Suggestions

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5 Conclusion

In this chapter we shall do a reference to an entry in the bibliography, `bibliography.bib`.

What we know of the invention of the flux capacitor is that Dr. Emmett Brown thought of this when hanging a clock in the bathroom. He was standing on his porcelain sink and slipped because it was wet, the resulting hit on the head was apparently a cause to this invention Brown (1955).

5.1 Future Work

The corresponding sketch made on this day has been attached in appendix C.

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A Solving For The Market Steady State

A.1 Steady State Flow Equations

- Fix some strategies s_m, s_w and let:

$$\rho_m(\mu, b) = \mathbb{E}_{\theta_w}\Big[s_m(\theta, \mu, b)\Big] = \iint\limits_{[0,1]^2} s_m(\theta, \mu, b)\, dG(\theta|\omega)\, dW(\omega; s),$$

- Let $R_b^m = \mathbb{P}(\mu \in (\mu', \mu''], b; s)$
  - I.e. agents with pizzaz $\mu \in (\mu', \mu'']$ and budget b
  - Eg. $R_b^m = M(\mu'', b; s) - M(\mu'', b-1; s) - M(\mu', b; s) + M(\mu', b-1; s)$
  - and $R_1^m = M(\mu'', 1) - M(\mu', 1)$
- Fix any $\mu', \mu'' \in [0, 1]$. For all $\mu \in (\mu', \mu'']$ the steady state male market must satisfy the following flow equations:

$$\underbrace{\frac{\lambda_m}{N_w}\Big(F_m(\mu'') - F_m(\mu')\Big)}_{\text{Enters platform}} = \underbrace{(1-\delta)\sum_{b=1}^{B} R_b^m}_{\text{Exogenous death}} + \underbrace{\delta R_1^m \int_{\mu'}^{\mu''} \rho_m(\mu, 1)\, dM(\mu; s)}_{\text{Expended budget}} \quad \text{(A.1)}$$

$$\underbrace{\delta R_{b+1}^m \int_{\mu'}^{\mu''} \rho_m(\mu, b+1)\, dM(\mu; s)}_{\text{Enters b}} = \underbrace{(1-\delta) R_b^m + \delta R_b^m \int_{\mu'}^{\mu''} \rho_m(\mu, b)\, dM(\mu; s)}_{\text{Leaves b}} \quad \text{(A.2)}$$

$$\underbrace{\frac{\lambda_m}{N_m}\Big(F_m(\mu'') - F_m(\mu')\Big)}_{\text{Enters platform}} = \underbrace{(1-\delta) R_B^m + \delta R_B^m \int_{\mu'}^{\mu''} \rho_m(\mu, B)\, dM(\mu; s)}_{\text{Leaves @ B}} \quad \text{(A.3)}$$

A.2 Solving for the Endogenous Type Distribution

- With an abuse of notation, let the probability of someone in R_b^m swiping right be:

$$\bar{\rho}_m(b) = \int_{\mu'}^{\mu''} \rho_m(u, b)\, dM(u; s)$$

- Solve for R_B^m from (A.3)

$$R_B^m = \frac{\lambda_m\Big(F_m(\mu'') - F_m(\mu')\Big)}{N_m\Big((1-\delta) + \delta\bar{\rho}_m(B)\Big)}$$

- Rearrange for R_b^m using (A.2)

$$R_b^m = \underbrace{\frac{\delta \bar{\rho}_m(b+1)}{\Big((1-\delta) + \delta \bar{\rho}_m(b)\Big)}}_{k_b} R_{b+1}^m$$

- By the above recurrence relation:

$$\begin{aligned} R_{B-1}^m &= k_{B-1} R_B^m \\ R_{B-2}^m &= k_{B-2} R_{B-1}^m \\ &= k_{B-2}(k_{B-1} R_B^m) \\ &\vdots \\ R_b^m &= R_B^m \prod_{i=1}^{B-b} k_{B-i} \end{aligned}$$

- Let $\mu'' = 1$ and $\mu' = 0$. Then $R_b^m = \mathbb{P}_m(b_m = b; s)$
- Given that b is discrete and the above defines a PMF, we also have:

$$\mathbb{P}_m(b_m = b; s) = R_B^m \prod_{i=1}^{B-b} k_{B-i}$$

$$\implies M_b(b; s) = R_B^m \sum_{j=1}^{b} \prod_{i=1}^{B-j} k_{B-i}$$

- Let $\mu'' = \mu$ and $\mu' = 0$. Then:

$$R_b^m = M(\theta, b; s) - M(\theta, b-1; s) = \mathbb{P}_m(\theta_m < \theta \cap b_m = b; s)$$

- By substituting the extended form for the above two cases and rearranging:

$$M_\theta(\theta | b_m = b; \mu, \omega) = \frac{\mathbb{P}_m(\theta_m < \theta \cap b_m = b; \mu, \omega)}{\mathbb{P}(b_m = b; \mu, \omega)} = F_m(\theta)$$

- To solve for $M(\theta, b; \mu, \omega)$

$$\begin{aligned} M(\theta, b; \mu, \omega) &= \sum_{j=1}^{b} M_\theta(\theta | b_m = j; \mu, \omega) \mathbb{P}_m(b_m = j; \mu, \omega) \\ &= F_m(\theta) R_B^m \sum_{j=1}^{b} \prod_{i=1}^{B-j} k_{B-i} \\ &= F_m(\theta) M_b(b; \mu, \omega) \end{aligned}$$

- Letting $b = B$, we get the marginal distribution for θ_m:

$$M(\theta, B; \mu, \omega) = F_m(\theta) M_b(B; \mu, \omega) = F_m(\theta) = M_\theta(\theta; \mu, \omega)$$

- Hence, we have:

$$\begin{aligned}
\mathbb{P}_m(b_m = b; \mu, \omega) &= \frac{\lambda_m}{N_m\Big(1-\delta(1-\rho_B^m)\Big)} \prod_{i=1}^{B-b} \frac{\delta \rho_{B-i+1}^m}{\Big(1-\delta(1-\rho_{B-i}^m)\Big)} \\
M_b(b; \mu, \omega) &= \sum_{i=1}^{b} \mathbb{P}_m(b_m = i; \mu, \omega) \\
M_\theta(\theta; \mu, \omega) &= F_m(\theta) \\
M(\theta, b; \mu, \omega) &= M_\theta(\theta; \mu, \omega) M_b(b; \mu, \omega)
\end{aligned}$$

Tying up The Steady State

- Consider the above arguments for the analogous case for women - Since we know the marginal attractiveness distribution for women in the steady state is equal to $F_w(\theta)$ then the expected probability of a right-swipe for men ρ_b^m is expressed as below, with an analogous expression for women

$$\rho_b^m = \int_{\Theta_w} \mu(\theta', b)\, dW_\theta(\theta'; \mu, \omega) = \int_{\Theta_w} \mu(\theta', b)\, dF_w(\theta')$$

- Substitute into the first set of flow equations to solve for - Furthermore, let:

$$\begin{aligned}
z_b^m &= \prod_{i=1}^{B-b} \frac{\delta \rho_{B-i+1}^m}{\Big(1-\delta(1-\rho_{B-i}^m)\Big)}, \quad \forall b = 1, ..., B_m - 1 \\
z_b^w &= \prod_{i=1}^{B-b} \frac{\delta \rho_{B-i+1}^w}{\Big(1-\delta(1-\rho_{B-i}^w)\Big)}, \quad \forall b = 1, ..., B_w - 1
\end{aligned}$$

$$z_B^m = \Big(1-\delta(1-\rho_B^m)\Big)$$

$$z_B^w = \Big(1-\delta(1-\rho_B^w)\Big)$$

- Then the steady state is given by:

$$N_m(\mu, \omega) = \lambda_m \left(\frac{z_B^m - \delta z_1^m \rho_1^m}{(1-\delta) z_B^m} \right)$$

$$N_w(\mu, \omega) = \lambda_w \left(\frac{z_B^w - \delta z_1^w \rho_1^w}{(1-\delta) z_B^w} \right)$$

$$M(\theta, b; \mu, \omega) = F_m(\theta) \left(\frac{(1-\delta)}{z_B^m - \delta z_1^m \rho_1^m} \right) \sum_{i=1}^{b} z_i^m$$

$$W(\theta, b; \mu, \omega) = F_w(\theta) \left(\frac{(1-\delta)}{z_B^w - \delta z_1^w \rho_1^w} \right) \sum_{i=1}^{b} z_i^w$$

B Uniqueness and Existence of Search Problem

C Notation

- Male types μ
- Female types ω
- Strategies $s = (s_m, s_w)$
- CDF's $M(\mu, b)$, $W(\omega, b)$
- Densities $m(\mu, b)$, $w(\omega, b)$
- Discount δ
- Population CDF's F_m, F_w
- Masses N_m, N_w
- Entry Flows λ_m, λ_w
- Tightness $\tau = \min\{\frac{N_w}{N_m}, 1\}$
- Effective discount α